

Report No. UT-02.07

4th South Street Viaduct Five Year Condition Inspection and Evaluation

Prepared For:

**Utah Department of Transportation
Research and Development Division**

and

**Salt Lake City Corporation
Salt Lake City, Utah**

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UDOT RESEARCH & DEVELOPMENT REPORT ABSTRACT

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16. Abstract <p>In November 1988, the rehabilitation of the 4th South Street Viaduct in Salt Lake City, Utah was completed and the bridge opened to traffic. Elements of the viaduct rehabilitation included the removal and replacement of delaminated concrete and installation of cathodic protection on the decks and substructures. Other repairs included the removal or replacement of the existing expansion joints, seismic upgrade, and sealing of the prestressed girder ends for corrosion control.</p> <p>A limited inspection of the 4th South Street Viaduct was conducted on September 17 and 18, 1993, in joint effort with Salt Lake City Public Works; Elgard Corporation, Chardon, Ohio; and CH2M HILL, Salt Lake City, Utah. The inspection was a voluntary effort by the participants with Salt Lake City Public Works providing the traffic control needed for the inspection. Weyher Brothers, the rehabilitation contractor, was also present during the evaluation to inspect the expansion joints for warranty repairs.</p> <p>The purpose of the inspection was to determine the overall condition of the bridge and the performance of the bridge rehabilitation methods and techniques utilized. The inspection included condition evaluations of the approach spans, deck overlays, shotcrete coating on the bents, girder end sealer condition and performance; and visual inspection of the expansion joints; and general bridge condition. Specific information desired to be obtained during the inspection was: 1) Corrosion activity and concrete delamination on the unprotected approach spans in comparison to the cathodically protected bridge decks; 2) Review shotcrete condition on the Bents to determine the extent of delaminations and their impact on the operation of the bent cathodic protection systems; 3) Close-up inspection of coating failures observed on the ends of the prestressed girders.</p> <p>Tests conducted during the inspection included chain drag delamination survey of all approach spans and several cathodically protected decks, shotcrete delamination surveys of several bents, visual inspection of the prestressed girder end sealer, and concrete coring at several locations on the approaches and decks. Visual inspection was conducted of the entire bridge to determine the performance of the rehabilitation techniques and methods utilized. Potential surveys were also conducted on Approach Nos. 2 and 3 and two bent columns to obtain more detailed data on their condition and corrosion activity or cathodic protection system performance.</p>					
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Introduction

In November 1988, the rehabilitation of the 4th South Street Viaduct in Salt Lake City, Utah was completed and the bridge opened to traffic. Elements of the viaduct rehabilitation included the removal and replacement of delaminated concrete and installation of cathodic protection on the decks and substructures. Other repairs included the removal or replacement of the existing expansion joints, seismic upgrade, and sealing of the prestressed girder ends for corrosion control.

A limited inspection of the 4th South Street Viaduct was conducted on September 17 and 18, 1993, in joint effort with Salt Lake City Public Works; Elgard Corporation, Chardon, Ohio; and CH2M HILL, Salt Lake City, Utah. The inspection was a voluntary effort by the participants with Salt Lake City Public Works providing the traffic control needed for the inspection. Weyher Brothers, the rehabilitation contractor, was also present during the evaluation to inspect the expansion joints for warranty repairs.

The purpose of the inspection was to determine the overall condition of the bridge and the performance of the bridge rehabilitation methods and techniques utilized. The inspection included condition evaluations of the approach spans, deck overlays, shotcrete coating on the bents, girder end sealer condition and performance; and visual inspection of the expansion joints; and general bridge condition. Specific information desired to be obtained during the inspection was:

- Corrosion activity and concrete delamination on the unprotected approach spans in comparison to the cathodically protected bridge decks.
- Review shotcrete condition on the Bents to determine the extent of delaminations and their impact on the operation of the bent cathodic protection systems.
- Close-up inspection of coating failures observed on the ends of the prestressed girders.

Tests conducted during the inspection included chain drag delamination survey of all approach spans and several cathodically protected decks, shotcrete delamination surveys of several bents, visual inspection of the prestressed girder end sealer, and concrete coring at several locations on the approaches and decks. Visual inspection was conducted of the entire bridge to determine the performance of the rehabilitation techniques and methods utilized. Potential surveys were also conducted on Approach Nos. 2 and 3 and two bent columns to obtain more detailed data on their condition and corrosion activity or cathodic protection system performance.

Summary

The overall condition of the 4th South Street Viaduct is very good. Although some maintenance and repairs are needed to maintain the present condition of the structure, the cathodic protection system is adequately protecting the decks and substructures from corrosion.

In comparison, the four approaches which were not cathodically protected are in very poor condition. Approach Nos. 1 and 4, which are concrete slabs on grade, were treated with a Latex Modified Concrete (LMC) overlay in 1981, but no additional repairs were performed during the 1988 bridge rehabilitation. These approaches were delaminated over 50 percent of the total deck area. The riding surface is still in relatively fair condition, although extensive concrete cracking and delamination could cause further degradation of the riding surface in the future.

Approach Nos. 2 and 3 were also overlaid with a LMC in 1981. However, during the 1988 bridge rehabilitation the LMC overlay was removed, concrete delaminations were removed by hydro-demolition, and the deck overlaid with the same low slump concrete placed on the cathodically protected spans. As a result, Approach Nos. 2 and 3 were in poor condition, but in significantly better condition than Approach Nos. 1 and 4.

A potential survey conducted on Approach Nos. 2 and 3 indicated active corrosion was occurring over a significant percentage of the deck surface. Approach No.3 had active corrosion occurring over 17 percent of the deck surface with concrete delaminations occurring on almost 2 percent of the deck. Approach No.2 had approximately 22 percent of the deck surface actively corroding and over 5 percent of the deck was delaminated. Accurate delamination quantities were not obtained on Approach No.2 because of difficulty in determining the extent of the delaminations. Concrete cores taken in Approach No.2 confirmed that the deck was delaminated.

In comparison to the four unprotected approaches, seven of ten cathodically protected decks did not have any concrete delaminations. The total delaminated area constituted less than 0.10 percent of the total protected deck area surveyed. Over 95 percent of the total delaminated area was located on Deck Nos. 4 and 5. A concrete core sample taken from a delamination in Deck No.5 indicated that it was an existing delamination which had not been removed and repaired during the 1988 rehabilitation work. Because many of the delaminations in the protected decks were generally small and difficult to detect, it is possible that the delaminations found were existing prior to the application of cathodic protection.

The substructure bents are cathodically protected similar to the decks, except that the titanium mesh anode was coated with a wet mix shotcrete overlay. Delamination of the shotcrete was detected over a large percentage of the bents surveyed. This was not a surprising find because cores taken approximately 6 months after rehabilitation was completed exhibited poor bond between the shotcrete and existing concrete substrate.

A corrosion potential survey conducted on two bent columns with disbonded shotcrete indicated the cathodic protection system is able to provide adequate corrosion protection to the reinforcement through the disbonded shotcrete. The bent columns surveyed were selected based on the method of shotcrete finish and magnitude of delaminations detected during the inspection.

The seal coating on the ends of the prestressed concrete girders is failing by peeling and cracking. This is permitting water and oxygen to enter the concrete and allow corrosion to continue on the exterior girders. Failure of the coating or continued reinforcement corrosion on interior girders was not observed. The primary cause of the coating failure on the exterior girders is water leakage from the deck expansion joints and poor resistance to water of the applied coating.

Repair of the expansion joints to correct the water leakage is recommended. Water leakage also appears to be a contributing factor to the shotcrete delamination and deterioration on the bent caps.

Observations and Conclusions

Bridge Decks and Approaches

Approaches

4th South Street Viaduct has four approaches; Approach Nos. 1 and 2 are on the east end of the structure and Approach Nos. 3 and 4 are on the west end. Unlike the bridge decks, none of the approaches were cathodically protected for corrosion control. Approach Nos. 1 (east) and 4 (west) are concrete slabs on grade and repair or rehabilitation of these spans was not included in the 1988 bridge rehabilitation work. The LMC overlay placed on these two approaches in 1981 is severely cracked and delaminated.

Rehabilitation work on Approach Nos. 2 and 3 included removal of the 1981 LMC overlay by mechanical scabbler followed with delamination removal by hydro-demolition. The poor concrete condition of the approaches in 1988 resulted in a significant quantity of steel reinforcement becoming exposed during hydro-demolition. The quantity of exposed steel would have required an extensive redesign of the cathodic protection system to avoid an electrical short between the anode and steel reinforcement. Because of time and budget limitations, it was decided to omit the cathodic protection system from Approach Nos. 2 and 3 and overlay the decks with a superplastized low slump concrete.

A delamination survey of Approach Span Nos. 1 and 4 indicated over 50 percent of the slabs were delaminated. The riding surface is still in reasonable condition, but is subject to extensive cracking and delamination. Although investigation into the cause of the delamination was not conducted during this inspection, it is suspected that continued corrosion of the reinforcement is causing the delaminations. This conclusion is based on the extent of corrosion activity observed on the adjacent approach spans. Delamination of the LMC overlay may also be a contributing factor to the magnitude of delaminations detected.

Approach Span Nos. 2 and 3 were also surveyed for delaminations. Approach No.3 was in the best condition with less than 2 percent of the deck subject to delamination. The greatest magnitude of delaminations was on Approach No.2 with greater than 5 percent of the surface area delaminated. Delamination testing was not completed on Approach No.2 because of difficulties in detecting the limits of the delaminated concrete.

Photographs Nos. 9,10, and 11 in the Appendix of this report shows the two concrete cores taken from Approach No.2. Both cores exhibited signs of delamination in the original concrete, but not at the interface between the overlay and existing concrete.

Concrete Core No.2 (Photo No.9) had two delaminations, one within the low slump concrete overlay and a deeper delamination within the original concrete at the bottom of the core. No conclusion is available as to the cause of the overlay fracture.

Potential surveys were conducted on Approach Nos. 2 and 3 to determine the magnitude and extent of corrosion activity on the steel reinforcement. Figure Nos. 1 and 2 show the results of the potential tests in an equi-potential contour map of each approach. The location and approximate size of delaminations detected on Approach No.3 are shown on Figure 2. Mapping of delaminations on Approach No.2 was not completed because of some uncertainty in establishing the limits of the delaminations.

Active corrosion on steel reinforcement is indicated when the potential is between -0.35 and -0.65 volts to a copper sulfate reference electrode. The more negative the reinforcement potential the greater the magnitude of corrosion and greater the risk that the concrete will become delaminated. Dark red colors show areas of the most active corrosion.

Areas in blue on Figure No. 1, show cathodically protected areas on a portion of Deck No. 1. The red areas adjacent to blue areas are not an indication of active corrosion. Cathodic protection causes the reinforcement to become more negative in potential with increasing current density collecting on the reinforcement. Cathodic protection current attenuates (decreases in density) rapidly with increasing distance from the anode mesh. This results in a similar attenuation of the electrical potential from protected to corroding (unprotected) potentials on the reinforcement. The red areas adjacent to the blue areas indicate that the reinforcement is receiving some cathodic protection current, but of insufficient magnitude for adequate corrosion protection.

Table 1 summarizes the surface area on each approach span at different levels of corrosion activity. As corrosion continues, those areas with possible corrosion activity will advance to more active levels of corrosion.

Corrosion activity and magnitude provides a general indication of the quantity of surface area that could be subject to delamination in the future. Active corrosion begins when the concrete's alkalinity is reduced below the threshold level that passivates and protects the steel reinforcement. Increases in corrosion rate and duration result in a heavy buildup of corrosion products around the steel reinforcement which exerts a force on the concrete. Delamination of the concrete occurs when the force of the corrosion products exceeds the tensile strength of the concrete.

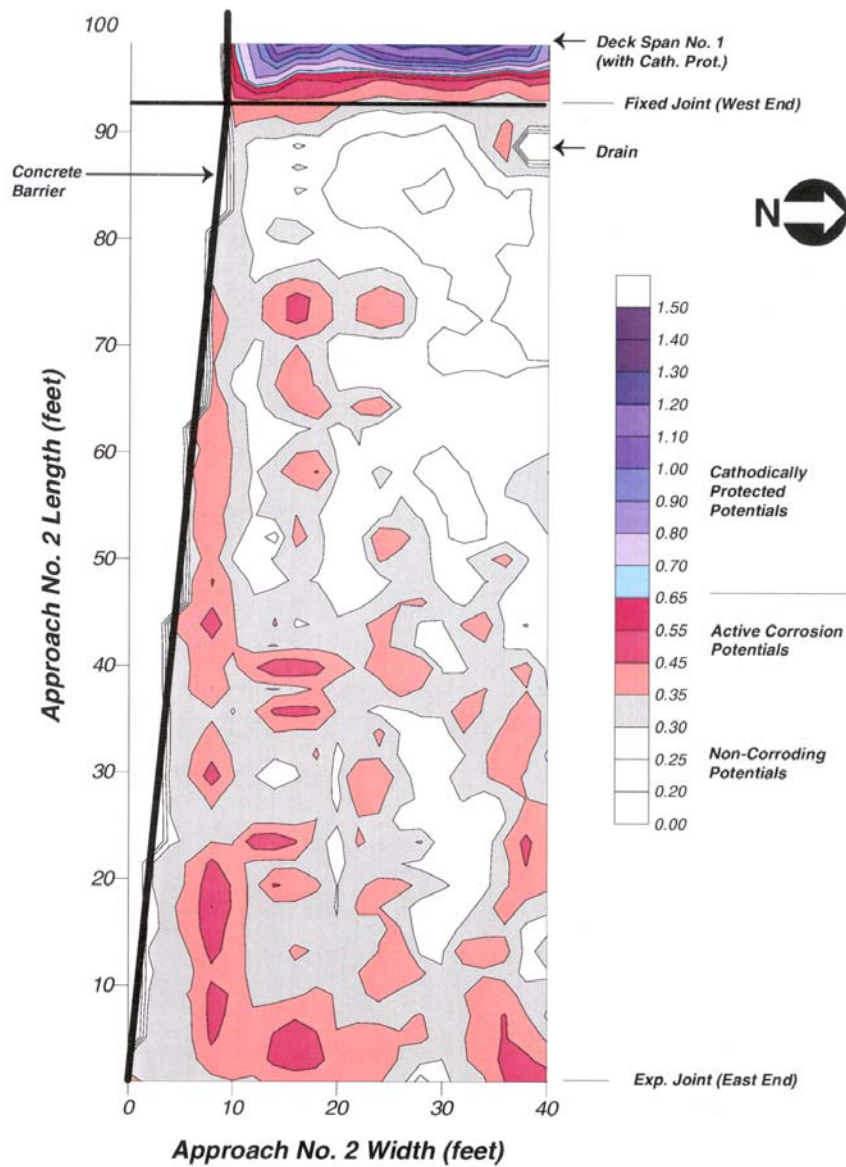


FIGURE 1

Potential Survey
4th South Street Viaduct

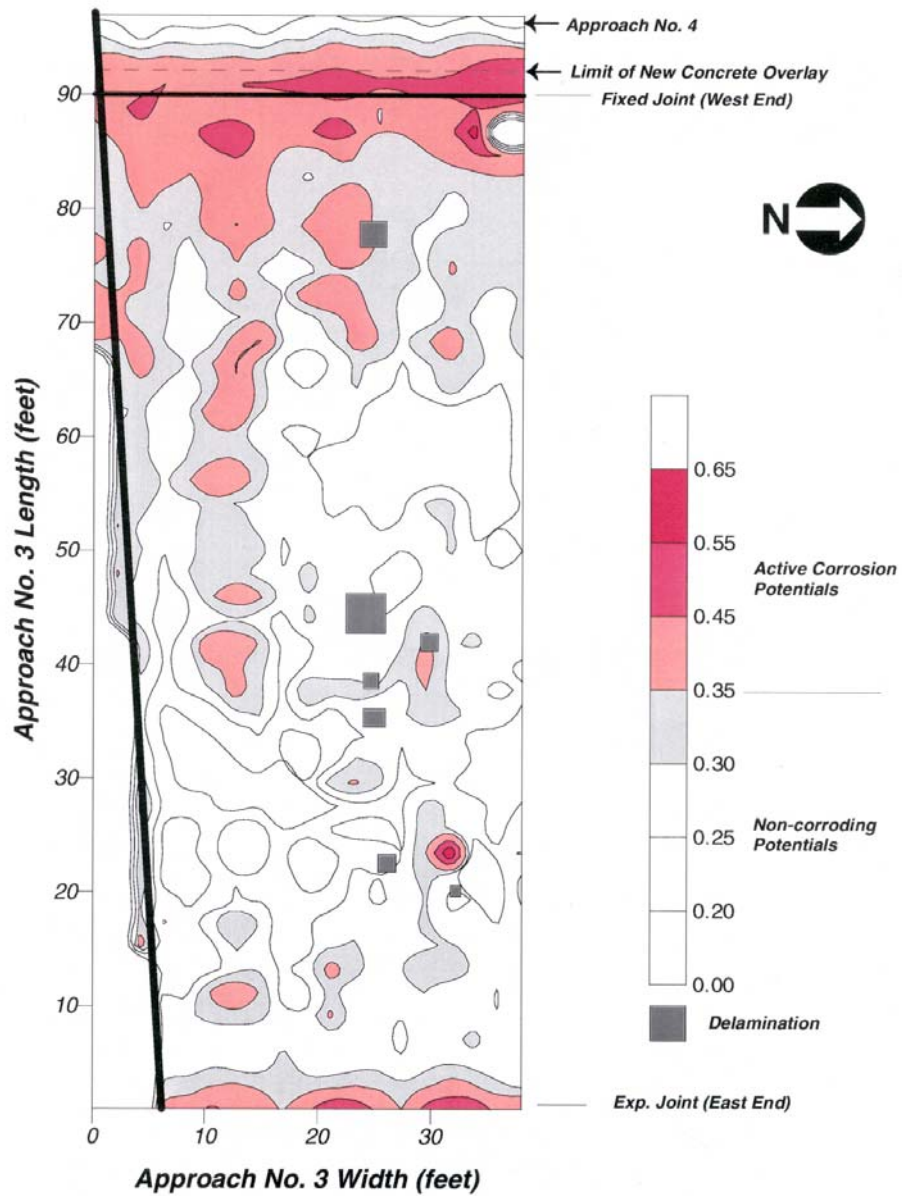


FIGURE 2

Potential Survey
4th South Street Viaduct

Table 1 Summary of Active Corrosion Areas on Approach Nos. 2 and 3				
Relative Corrosion Activity	Approach 2		Approach 3	
	Area (ft ²)	Percent (%)	Area (ft ²)	Percent (%)
Possible Corrosion (-0.30 to -0.35v)	1,253	31%	839	23%
Active Corrosion (-0.35 to -0.45v)	744	19%	548	15%
Very Active Corrosion (-0.45 to -0.55v)	121	3%	88	2%
Extremely Active Corrosion (-0.55 to -0.65v)	17	0%	2	0%
TOTAL ACTIVE CORROSION	882	22%	638	17%

The strength of the concrete will affect the rate and duration of corrosion required to cause a delamination to occur. Previous studies on the 4th South Street Viaduct had indicated that potentials over -0.45 volts resulted in a moderate probability of delamination, but areas with potentials over -0.55 volts had a very high probability of delamination. It could be possible to have extremely active corrosion areas continue for an extended period of time without delaminating. Because concrete delaminations are caused by pressure exerted from the accumulation of corrosion products, the duration of the corrosion activity is the most significant factor in the location and magnitude of delaminations in the concrete deck.

Bridge Decks

During rehabilitation of the Viaduct in 1988, each of the concrete and steel girder supported bridge decks were rehabilitated and protected from corrosion with an impressed current cathodic protection system. As part of the bridge deck rehabilitation, delaminations were located, removed by hydro-demolition, and patched. The deck surface was then cleaned and profiled by hydro-scarification prior to placing the titanium mesh cathodic protection system over the deck surface and overlaying with superplastized low slump concrete.

The cathodic protection system on the bridge decks has been in operation since January 1989 and has been checked and maintained on a monthly basis since energizing was completed. All of the decks meet or exceed the 100 millivolt depolarization criteria for adequate corrosion protection.

All of the deck cathodic protection zones have been operational without any downtime since they were first energized. An exception is Rectifier No.9 which was de-energized for approximately one year while an electrical short in the AC power supply wires was located and repaired. Rectifier No.9 provides cathodic protection to Deck No.25 and Bent No.25.

A delamination survey, using the chain drag technique, was conducted on 10 of 25 cathodically protected decks; four steel girder and six concrete girder decks. No delaminations were found on the concrete girder decks. This is consistent with the observations made on the magnitude of delamination during rehabilitation, where the concrete girder decks had a significantly lower percentage of delaminated surface area than the steel supported decks. Delamination surveys were conducted on Deck Nos. 4,5, 11, and 12 (steel girder) and Deck Nos. 2,3, 13, 14, 15, and 16 (concrete girder).

All of the delaminations located on cathodically protected decks were on the steel girder decks, with 95 percent of the delaminations located on Deck Nos. 4 and 5. A small, 1 square foot, delamination was found on Deck No. 12, but it was very tight and difficult to determine if it was actually delaminated. No delaminations were found on Deck No.11.

Two concrete cores were removed from Deck No.5, one in a delaminated area and the other in a sound area. The delaminated core indicated that the delamination was near the steel reinforcement. Closer inspection of the delaminated surface on the core indicated the presence of cement paste over the delaminated surface. This paste condition was similar to that which occurred during the hydro-scarification or demolition work. Presence of a similar cementitious paste was not observed on the delaminated concrete cores taken from Approach No.2. It is very possible that the delaminations on Deck Nos. 4 and 5 are previous delaminations that had not been removed and repaired during the 1988 bridge rehabilitation work. Photographs Nos. 12, 13 and 14 in the Appendix show the cores removed from Deck No.5.

Decks No.4 and 5 were among the last decks to have delaminations removed and patched during the 1988 rehabilitation work. Because delamination quantities were exceeding the contract quantities, there was an increasing desire to minimize the quantity of delaminations removed and repaired to limit the budget overrun. In addition, the steel girder decks had an exceedingly high quantity of delaminations in comparison to concrete girder decks.

The total area of delamination and percentage of deck area is tabulated for the steel spans in Table 2.

The total quantity of delamination found on the cathodically protected decks surveyed was 27 square feet. A total of 34,382 square feet of cathodically protected deck surface was included in the delamination survey.

Table 2
Summary of Cathodically Protected Bridge Deck
Delaminations

Deck Number	Deck Surface Area (ft²)	Delaminated Area (ft²)	Percentage of Deck Delaminated
2	2,795	0	0.0%
3	2,795	0	0.0%
4	4,230	7	0.2%
5	4,230	19	0.4%
11	4,800	0	0.0%
12	4,350	1	0.0%
13	2,795	0	0.0%
14	2,975	0	0.0%
15	2,795	0	0.0%
16	2,795	0	0.0%
Total	34,382	27	0.1%

Deck Expansion Joints

The deck expansion joints are performing well, but continue to need cleaning and periodic repairs to fix cuts and tears in the rubber glands. Problems with the expansion joint installation observed during the bridge evaluation were corrected on October 14, 1993, under the expansion joint warranty .

Water leakage from the ends of the expansion joints has contributed to the deterioration of the shotcrete on the bent caps and continued corrosion of the concrete girder ends. Leakage from the expansion joint on the south side of the bridge is caused by openings in the concrete parapet adjacent to the expansion joint gland supports. Although the expansion joint is bent upward to help contain water, openings in the concrete parapet allow water to bypass the expansion joint and run onto the substructures.

On the north side of the bridge, the expansion joint is bent up within the middle parapet to provide some containment of water, but remains flat through the sidewalk and northern parapet. This allows water to run from the sidewalk and traffic lanes onto the bent cap below.

Repairs to the expansion joint are needed to control the water leakage onto the substructures. Repairs would require filling the openings in the south parapets with polymer concrete and providing drainage systems on the north side of the bridge to direct water off the substructures.

Bridge Substructures

Nineteen bridge substructures are cathodically protected with a titanium mesh cathodic protection system which was overlaid with a wet mix shotcrete. Cathodic protection current is supplied to the bent from a single rectifier circuit and then divided between the cap, south column, and north column through three 50-watt slide wire resistors.

Problems with the substructure cathodic protection system operation has been a periodic loss of the resistor for the pier caps. Because of the magnitude of current required on the pier cap, excessive heat generated in the resistor eventually causes the resistor to electrically open. Resistors are easily replaced during the normal monthly monitoring of the cathodic protection system. An average of 3 to 4 resistors are replaced each year.

All of the cathodic protection stations on the substructures have continued to operate in a relatively stable and consistent mode. Minor adjustments have been periodically required on the resistors or total current output from the rectifier. No bent cathodic protection system has been non- operational for a period of time greater than two months, except for Bent No.25 which was de- energized for approximately one year while the electrical system short was repaired.

Several months after the cathodic protection systems were installed and energized on the bridge substructures, concrete cores were taken to determine the bond strength between the shotcrete and existing concrete structure. Only one of the four concrete cores taken had sufficient bond strength to permit removal of the core without separation of the shotcrete from the concrete substrate.

The shotcrete has been watched closely over the last 5 years to determine if it would fail or reduce the effectiveness of the cathodic protection system in providing adequate corrosion protection to the structure. Failure of the shotcrete has not occurred, although cracking and disbonding has been observed. The cathodic protection system continues to provide adequate protection with no observed degradation of performance.

To verify the performance of the cathodic protection system, two bent columns were tested to determine the magnitude of polarization that has occurred under disbonded shotcrete. Bent Nos. 7 and Bent 9 were selected because of the difference in shotcrete finishing methods used for the two bents and the magnitude of delaminations detected on the columns.

A potential survey was conducted on a grid basis over the lower 7 feet of the north columns. The first step of the test was to measure the "instant off" potential on a one foot grid around the full circumference of the column. After the rectifier had been de-energized for 4 hours, a second potential survey was conducted at the same locations to obtain the depolarized potential. The difference between the two readings at each node on the grid was calculated to determine the depolarized potential change.

Figures Nos. 3 and 4 shows an equi-potential contour map of the depolarized potential changes that occurred on Bents Nos. 7 and 9 respectively. A depolarized potential change of -100 millivolts or more indicates adequate corrosion protection was achieved. Both of the bent columns were adequately protected even under the disbonded shotcrete. Delamination locations were mapped and shown on the figures to indicate their location and size with respect to the depolarized potential values.

The two red locations on Figure No.4 (Bent No.9) indicated areas where the depolarized potential change was less than -100 millivolts. In both locations the poorly protected areas were located outside the delaminated areas and were at ground level. Because these areas showed some polarization, corrosion rate of the reinforcement has been slowed significantly but may not be fully mitigated.

Other problems observed with the shotcrete is the breakdown of the shotcrete cementitious matrix in the bent caps where water from the bridge deck runs onto the cap. This was observed at several bents and all were located at expansion joints in the bridge deck. Why the cementitious matrix of the shotcrete has degraded is not known. Petrographic testing was not feasible on the degraded shotcrete samples collected.

Problems with the substructure condition all appear to correlated with drainage problems at the expansion joints. Many of the delaminated shotcrete areas also appeared to be associated with water runoff, but not consistently. It is theorized that water could be contributing to the growing loss of bond between the shotcrete and the concrete substrate.

Concrete Girders

Each of the concrete girders were corroding and spilling as a result of salt in the water runoff through failed expansion joints prior to the 1988 rehabilitation of the bridge. As part of the bridge rehabilitation, many of the expansion joints were removed and a fixed joint installed along with a concrete diaphragm between the girders.

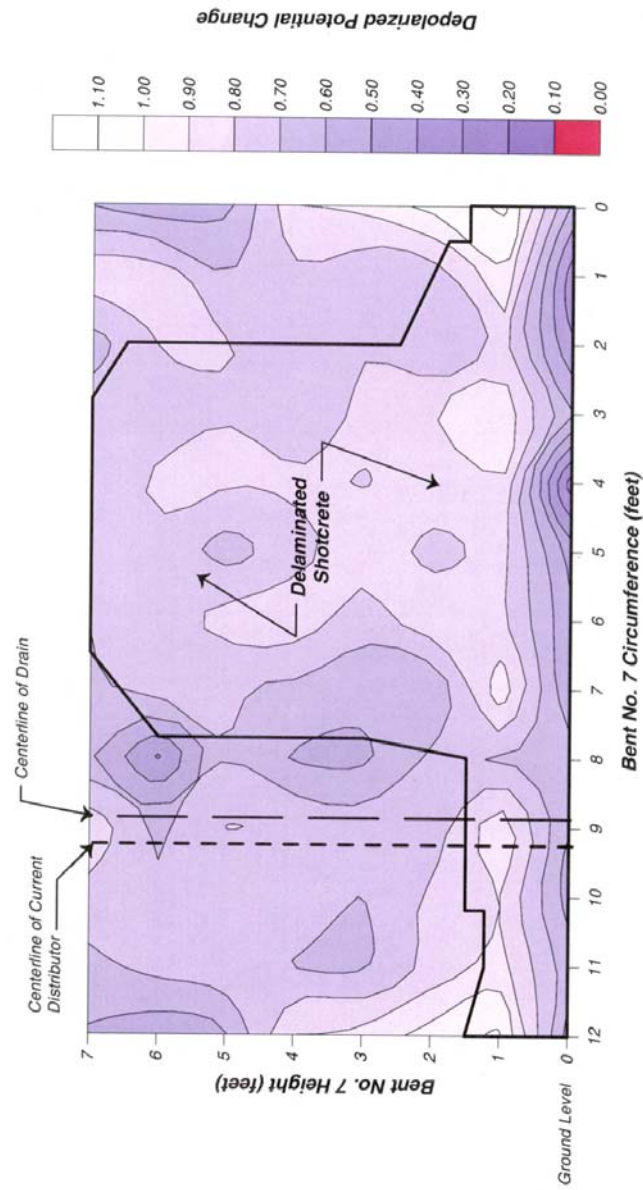


FIGURE 3
Bent No. 7
North Column Depolarized Potential Survey
4th South Street Viaduct

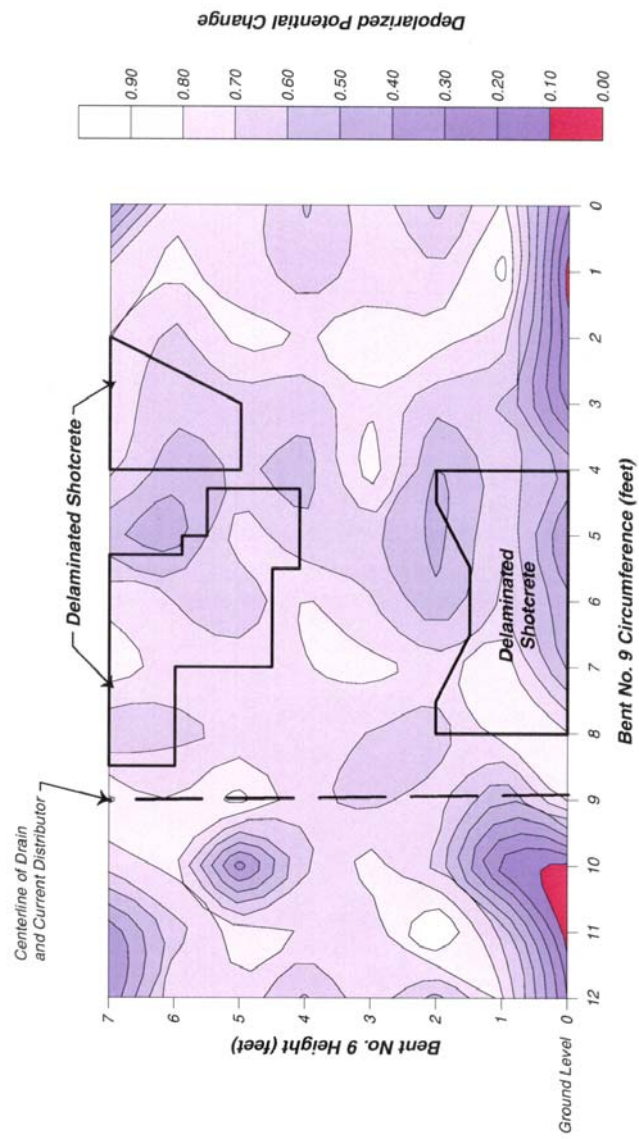


FIGURE 4

Bent No. 9
North Column Depolarized Potential Survey
4th South Street Viaduct

Steel reinforcement will continue to corrode in salt-contaminated concrete even after the water source has been removed. Because the girders are prestressed, there was a concern that the application of cathodic protection could cause hydrogen embrittlement of the wires or even loss of concrete bond. Therefore, a seal coat was applied to the ends of each girder to restrict oxygen diffusion into the concrete in an attempt to slow the rate of corrosion.

The seal coat appears to be performing well where water is prevented from running over the coating. The girder ends and seal coat were in very good condition on the interior girders and signs of concrete distress from continued prestressing wire corrosion was not observed. Cracking of the concrete and corrosion product staining was observed primarily on the exterior girders where water from the expansion joints was continuing to run over the ends of the girders. Problems observed included peeling of the coating, cracking, and rust staining.

Because the seal coating is failing on the exterior girders, corrosion of the prestressed girders will continue to increase in rate. Based on the magnitude of concrete distress observed, achievement of a 40-year service life will not be possible without consideration of a repair and improved coating system for sealing the girder ends. In addition, repair of the expansion joints to eliminate water runoff will be required.

Conclusions

The primary conclusion obtained from the 5-year inspection of the 4th South Street Viaduct is that the cathodic protection system is highly effectively in mitigating corrosion and concrete delamination of the bridge decks and substructures. Sealing of the concrete girder ends has been effective in slowing corrosion, but the rate of deterioration is continuing to progress at a greater rate than is desirable to achieve the goal of an additional 35 years of service from the structure.

Other conclusions reached from the inspection are:

Cathodic protection effectively reduced the propagation and development of delaminations in the concrete deck.

Delaminations in the concrete deck or shotcrete overcoat did not impair the effectiveness of the cathodic protection system in providing adequate corrosion protection to the steel reinforcement.

Operation of the cathodic protection system has been relatively consistent and required only minor maintenance. Because of its operational stability, bi-monthly monitoring checks would be sufficient.

Proper deck and sidewalk drainage is critical to the successful performance of the substructure corrosion protection systems.

Sealing of the concrete girder ends will provided a limited increase in life, but will not achieve the 35 years of additional service desired unless the girder ends are repaired and an improved seal coating applied.

Overall, the methods utilized in rehabilitating the bridge are providing the corrosion protection intended and exhibiting excellent durability .The rehabilitation methods utilized on the 4th South Street Viaduct are considered state-of-the-art methods and techniques today as reported in the Strategic Highway Research Program's report on Cathodic Protection of Reinforced Concrete Bridge Elements (SHRP-S-337), dated January 1993.

Recommendations

Recommendations for the continued maintenance of the 4th South Street Viaduct include the following repairs and modifications:

- Correct the water leakage at the deck expansion joints on the north and south side of the bridge.
- Modify the cathodic protection monitoring program to a bi-monthly test. During the tests it will be important to correct all deficiencies detected and make any adjustments required to insure that total downtime of the cathodic protection systems remains very short.
- Approach Nos. 1 and 4 can continue to be utilized in their present condition for a limited period of time, although budgeting for the future removal and replacement of the slabs should be considered.
- Approach Nos. 2 and 3 are still in fair condition with limited delamination of the concrete deck. However, as the rate of corrosion activity increases in both rate and duration, growth in the quantity of delaminations will continue unless cathodic protection is added to mitigate the corrosion activity. If cathodic protection is installed in the very near future, delamination repair costs associated with the cathodic protection system installation will be minimized. A recommended cathodic protection system for Approach Nos. 2 and 3 is a slotted ribbon system, which would eliminate the need for a concrete overlay.
- Continue to monitor the shotcrete on the substructures for deterioration and failure. Careful evaluation of the cathodic protection monitoring data should be continued for early detection of problems with the shotcrete.
- Repair the shotcrete on the bents which has been deteriorated from water runoff. Removal and replacement of delaminated shotcrete is not required at this time.
- Review the exterior concrete girders to determine the best method for mitigating the corrosion on the ends. Review should include evaluation of the risks associated with prestressed wire failure and the extent of corrosion protection required to achieve another 35 years of service.

APPENDIX

Photographs

PHOTOGRAPHS

4TH SOUTH STREET VIADUCT -5 YEAR INSPECTION



Photo No. 1 Approach No.1 with latex modified concrete overlay. Overlay is in fair condition with extensive cracking and approximately 50 percent delaminations as indicated by the white markings.



Photo No. 2 Approach No. 4 looking east, white markings indicate delaminated areas detected with a chain drag survey.

PHOTOGRAPHS

4TH SOUTH STREET VIADUCT -5 YEAR INSPECTION



Photo No. 3 Cathodically protected Deck No.5, delaminations indicated by white marks. The two white spots on the deck are concrete core locations.

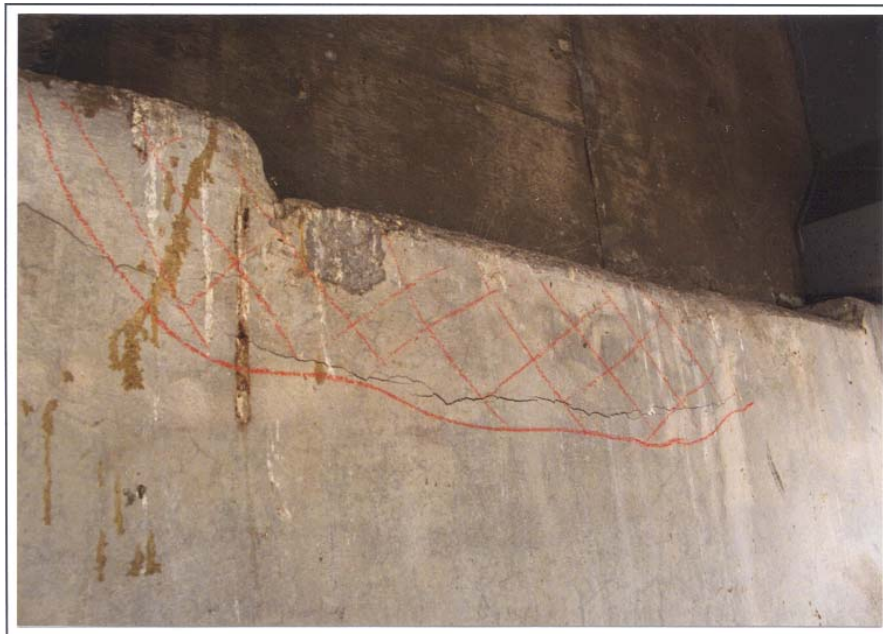


Photo No. 4 Bent No.7 cap on east side. Red marking indicates a delaminated area. Note the crack across the delamination.

PHOTOGRAPHS

4TH SOUTH STREET VIADUCT -5 YEAR INSPECTION



Photo No. 5

Bent No. 10 (looking east) showing water damage along the west side of the cap and breakdown of cement matrix on end of cap.

Photo No. 6

End view of Bent No. 10 cap showing the severe cracking and delamination of the shotcrete from water runoff. Breakdown of cement matrix on the top of the cap not visible in photo.



PHOTOGRAPHS

4TH SOUTH STREET VIADUCT -5 YEAR INSPECTION



Photo No. 7 Chemical attack of shotcrete on the south side, bottom of the column. Shotcrete is soft and easily removed. Yellow crystals are growing between the shotcrete and concrete substrate.



Photo No. 8 Concrete Cores No.1 and No.2 taken from Approach No.2 and Core No.3 and No.4 taken from Deck No.5.

PHOTOGRAPHS

4TH SOUTH STREET VIADUCT -5 YEAR INSPECTION



Photo No. 9 Side view of cores from Approach No.2. Note the double delamination in Core No.2 (right).



Photo No.10 End view of the core bottoms, core on right has a double delamination. Photo shows the second (deepest) delamination surface.

PHOTOGRAPHS

4TH SOUTH STREET VIADUCT -5 YEAR INSPECTION



Photo No.11 Close-up of first (upper) delamination in the low slump overlay of Core No.2. The left half is the top portion of the core and the right half is the lower portion.



Photo No.12 End view of the Deck No.5 cores. Core No.3 is located on the left and Core No.4 is on the right.

PHOTOGRAPHS

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Photo No.13 End of Core No.3 (delaminated core). Cement paste on the fracture surface indicates fracture may be from an existing delamination that was not repaired during rehabilitation



Photo No.14 End of Core No.4 from a non-delaminated area on Deck No.5. Reinforcement corrosion products on core are from corrosion activity prior to the application of cathodic protection. Cathodic protection will not remove existing corrosion products.